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ABSTRACT

This study examined the cognitive impact of implementing a computer algebra system (CAS) on six intermediate algebra classes at Orange Coast College (California). The control group of three classes was taught using the traditional method of instruction and scientific calculators. The other three classes were the experimental group and were taught using the computer-based system known as CAS TI-89. The research was conducted as a quasi-experimental nonrandomized control group pretest-posttest design. The posttest results indicated no statistically significant difference in mean scores for the capability to perform mathematics by hand between the control and experimental groups. Also, analyses of chapter examinations indicated no statistically significant difference in mean scores regarding the capability to perform algebraic manipulation by hand between the control and experimental groups. However, there was a statistically significant difference in mean scores indicating that the experimental group outperformed the control group in their ability to solve higher-order reasoning skills problems by hand. (KP)

THE COGNITIVE IMPACT OF A COMPUTER ALGEBRA SYSTEM ON INTERMEDIATE ALGEBRA STUDENTS AT THE COMMUNITY COLLEGE LEVEL

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ABSTRACT

Problem and design. Beginning in June, 1999 and commencing in December 1999, six Intermediate Algebra classes were involved in a study of the effects of implementing a computer algebra system (CAS) in intermediate algebra. Three classes were in the control group and three classes were in the experimental group. The experimental group (N = 70) was taught using the CAS TI-89 and the control group (N = 65) was taught with the traditional method of instruction and a scientific calculator. The research was a quasi-experimental nonrandomized control-group pretest-posttest design.

Findings. Posttest results indicated no statistically significant difference in mean scores for the capability to perform mathematics by hand between the control group and the experimental group.

Analysis of chapter examinations indicated no statistically significant difference in mean scores regarding the capability to perform algebraic manipulation by hand between the control group and experimental group, or in the ability to perform graphical analysis by hand between the control group and experimental group. However, there was a statistically significant difference in mean scores indicating the experimental group outperformed the control group in their ability to solve higher-order reasoning skills problems by hand.

METHODOLOGY AND PROCEDURES

Sample

The sample of individuals involved in this study consisted of students enrolled in intermediate algebra at Orange Coast College (OCC), a 2-year community college in Southern California. The control group received the traditional format of instruction consisting of 65 students, and the experimental group of 70 students received the treatment of classroom instruction with the TI-89 graphing calculator.

Instructional Design of the Classroom

The Control Group.

The control group received the traditional method of instruction normally encountered in a mathematics classroom. Homework questions were addressed at the beginning of the class, followed by lecture of new material. Examples were presented on the chalkboard that demonstrated the topic(s) being learned. Students were encouraged to ask questions. Dialogue between the students and researcher during the presentation was welcome and frequent. During class, students would occasionally work together in groups and work on problems being learned in that lesson. During this time, the researcher would walk around the room and assist groups with their questions and difficulties. When possible, the researcher tied the topics being learned to real-world applications so that students could see that what they were learning was used in realistic settings.

The Experimental Group.

The experimental group experienced the exact same format in terms of covering homework at the beginning of the period, interaction during the lesson, working in groups, and presentation of real-life applications. However, they received instruction

that implemented the TI-89. The TI-89 was utilized during every class in a variety of formats. Some lessons were taught entirely through its use; other lessons incorporated examples both on the chalkboard and on the TI-89, and some lessons used only the calculator to check hand-derived solutions to problems encountered. It is important to note that the TI-89 was an integral part of every lesson, every day, regardless of the degree implemented. It was the researcher's intent to employ the TI-89 as an opportunity to learn through discovery with a hands-on approach. Learning mathematics in a traditional classroom typically entails the instructor showing the students an algorithm of how to do a particular type of problem. In the experimental class, the algorithms, when possible, were derived using inductive reasoning.

Every effort was taken to make the environment of the control and experimental groups comparable. Only the instructional style was different. The textbook, the examples used when teaching new material, and the time spent going over homework were all the same for both groups. Homework assignments were the same, with the exception of an occasional graphing calculator or computer algebra system (CAS) problem assigned to the experimental group that was contrived by the researcher. The textbook used in this study did not have exercises for CAS use.

No attempt was made artificially to skew results to favor one group over the other. The researcher had a professional and ethical interest in teaching students to the best of his ability in both groups, not at producing particular results. After all, students being successful in mathematics was the central goal of this study.

Administration of the Pretest

Students involved in the study were given the same pretest on the first day of class. The pretest, a 38 question multiple-choice examination written by the mathematics department at OCC, is given to all intermediate algebra students on the first day of class. All OCC mathematics students from prealgebra to calculus take diagnostic examinations similar to the one given in this study at the beginning of the semester. Therefore, subjects in the study would not be alerted to anything out of the ordinary when they took the pretest.

Administration of the Posttest

The posttest was the University of California's Mathematics Diagnostic Testing Project for Intermediate Algebra ("Mathematics Diagnostic," 1986), a 45 question multiple-choice examination covering topics from intermediate algebra. It was administered as the final examination on the last day of the semester.

Administration of Chapter Examinations

Four examinations covering two to three chapters each were administered over the course of the semester. Both groups took a portion of the examination with a calculator and a portion of the examination without a calculator. The members of the control group used a scientific calculator on their calculator portion of the examination and the experimental group used the TI-89 on their calculator portion of the examination. Although the tests for the two groups were different, approximately 7 out of 10 items on each test were identical or very similar by taking into account such matters as common error patterns. Consisting of multiple-choice and performance-based formats, these questions were used for comparison to determine whether any differences in mathematical performance existed between the two groups. For consistency,

performance-based solutions were scored using a scoring rubric. Only questions where both groups answered them without the aid of any calculator were compared.

These questions fell into three main categories: (a) algebraic manipulation, (b) graphical analysis, and (c) higher-order reasoning skills. Approximately 50 points comprised algebraic skills, 10 to 15 points dealt with graphical analysis, and 10 to 15 points consisted of higher-order thinking skills. Algebraic manipulation consisted of routine problems such as factoring, expanding, combining like terms, and simplifying. Graphical analysis covered topics like the drawing of lines, conic sections, and exponential and logarithmic functions. Students may also have been given a graphical application and may have been asked to answer questions by interpreting what they saw. Higher-order reasoning questions covered a variety of areas including proofs, or answering questions of a 'why?' and 'how come?' type of format. The questions that fell into more than one category were placed into the category most nearly resembling their structure and format.

The control group from the summer session took the examinations first, followed by the experimental group in the subsequent class period. During the fall semester, the experimental group took the examinations first, followed by the control group the next day. Care was taken to ensure parts of the examination not used for comparison were similar in difficulty. It is the opinion of the researcher that both groups took examinations that were comparable in their mathematical complexity.

RESULTS

The results from the study are indicated in the following table and accompanying analysis. An alpha level of .05 was used for all statistical significance. Two-tailed t-tests were implemented since data was normally distributed. All means were student raw scores converted to percentage scores as indicated on examinations.

Analysis of Data

Difference in Mean Scores Between the Experimental Group and the Control Group

As indicated in Table 1, there was no statistically significant difference between mean scores of the experimental group and the control group on the pretest and posttest. Likewise, there was no statistically significant difference in mean scores on the chapter examinations in the areas of algebraic skills or graphical analysis. However, the difference in mean scores on the chapter examinations for the variable of higher-order reasoning skills was statistically significant with the experimental group outperforming the control group.

TABLE 1

A Comparison of the Mean Scores of the Total Experimental Group and of the Total Control Group on Each of the Five Achievement Measures in Mathematics

Achievement Measure	Experimental Group (N = 70)		Control Group (N = 65)		M_1-M_2	t (133)	p
	M_1	SD_1	M_2	SD_2			
OCC Pretest	59.52	15.07	60.12	13.02	-0.60	-0.24	0.81
UNIV Calif. Posttest	62.44	15.29	62.75	17.92	-0.31	-0.11	0.91
Chapter Test: Algebraic Skills	62.82	14.17	64.27	13.49	-1.45	-0.61	0.54
Chapter Test: Graphical Analysis	62.41	20.67	55.91	18.76	6.50	1.91	0.06
Chapter Test: Higher-Order Reasoning Skills	69.98	17.95	62.91	14.56	7.07	2.50	0.01

Conclusions

At the core of this research project was the effect of a CAS on mathematical development. Would it be detrimental to students' ability to perform mathematical manipulation by hand?

Pretest results, along with surveys given at the beginning of each semester, indicated the experimental and control groups were remarkably similar in (a) mathematical ability, (b) amount of elapsed time since enrollment in their last mathematics course, (c) mathematics and test anxiety, and (d) preference in learning styles. In addition, rates of completion for homework during the semester between the control group (M = 72.04, SD = 26.76) and the experimental group (M = 72.01, SD = 28.84) were virtually identical, $t(133) = 0.01$, $p = 1.00$.

Posttest results indicated no statistically significant difference in the capabilities to perform mathematics by hand between the control group (M = 62.75) and experimental group (M = 62.44). Analysis of scores on chapter examinations yielded no statistically significant difference in the capability to perform algebraic manipulation by hand between the control group (M = 64.27) and experimental group (M = 62.82) or the ability to perform graphical analysis by hand, (M = 55.91) and (M = 62.41) respectively.

However, the experimental group (M = 69.98) outperformed the control group (M = 62.91) at a statistically significant level (p = .01) in their performance of higher-order reasoning skills by hand. It is believed that the instructional implementation of the TI-89 led to this difference. Students were actively involved in the learning process, not merely sitting and absorbing knowledge. Higher-order thinking was being developed throughout the learning sequence. Students were testing hypotheses, observing patterns,

making conjectures through the use of inductive reasoning, and discovering the properties of mathematics through active, guided instruction.

It is also evident that the experimental group probably outperformed the control group in the category of graphical analysis. Although the evidence was not statistically significant ($p = 0.06$), the suggestion of practical significance of this result is intriguing.

REFERENCES

Mathematics Diagnostic Testing Project. (1986). The Regents of the University of California at San Diego and the Trustees of the California State University. San Diego: University of California.

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